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THE EFFECTS OF NOISE ON HUMAN BEHAVIOR

WPAFB, O.

JOHN F. CORSO
THE PENNSYLVANIA STATE COLLEGE

DECEMBER 1952

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WADC TECHNICAL REPORT 53-81

THE EFFECTS OF NOISE ON HUMAN BEHAVIOR

John F. Corso
The Pennsylvania State College

December 1952

Aero Medical Laboratory
Contract No. AF 33(038)-786
RDO No. 695-63

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

The investigations herein reported were conducted by the psychology section of The Pennsylvania State College research project on the "Effects of Vibration on AF Personnel", supported by the USAF under Contract No. AF 33(038)-786, RDO No. R-695-63, with Major H. O. Parrack, project engineer. The report includes experimental work completed from the inception of the project on 24 March 1949 through 31 October 1952.

The author of this report was in no way responsible for the research undertaken, but is attempting to summarize the studies dealing with the effects of noise on human behavior. (A subsequent report covering the same period will be prepared by Dr. E. B. Hale on the effects of noise on animal behavior.) Acknowledgment is made to the original investigators, Drs. K. R. Smith, A. M. Barrett, C. J. Stambaugh, Jr., T. Blau, H. G. Miller, Mr. J. L. Kobrick, and to the many others who contributed to the successful completion of this phase of the research program.

ABSTRACT

The present report is a comprehensive summary of a program of research undertaken in the Department of Psychology of The Pennsylvania State College from 24 March 1949 to 31 October 1952 on the effects of high intensity noise on human behavior. In all, six major studies were conducted and are reviewed, with the following information provided for each study; (1) abstract, (2) purpose, (3) procedure, (4) results and conclusions, and (5) summary statement. In general, the results of this series of studies show that noise has no marked effect on mental performance and that individual differences in noise susceptibility are unrelated to personality characteristics. There is some indication that a relationship exists between noise susceptibility and functional level of the autonomic nervous system.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

Robert H. Blount

ROBERT H. BLOUNT
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

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SECTION I

INTRODUCTION

The effect of noise on man has long been a problem of considerable interest to psychologists and specialists in many professional areas. Until the time of World War II, however, most studies conducted on this problem were either concerned with the role of industrial noise on worker productivity (2,[1] 3, 4, 27, 34, 37, 39, 40, 41, 43, 58, 63, 66, 70, 71) or with the effects of acoustical engineering on the reduction of ambient noise levels (7, 19, 23, 24, 30, 31, 32, 35, 36, 42, 46, 47, 53, 54, 55, 57, 61, 72). With the onset of the war, the possibility that noise might seriously impair military effectiveness directed attention to the problem of noise control in mechanized vehicles, aircraft, and warships (5, 6, 8, 9, 10, 11, 15, 20, 21, 29, 45, 56, 60). The current development-production of jet-type engines has served to redirect and intensify research efforts in this area. Attempts are now being made to determine the effects of high intensity sonic and ultrasonic frequencies on the behavior of biological organisms (1, 14, 16, 18, 22, 25, 26, 38, 49, 50, 51, 67, 68) and to establish valid criteria for the specification of human limits of noise tolerance (12, 17, 44, 52, 59, 62).

The increased emphasis placed on the general problem of the effects of noise on man has provided a rapidly expanding body of material which has been summarized in two recent literature surveys. In 1946 Berrien (13) reviewed the literature dealing with the effects of intense sound on human performance, with major emphasis on studies conducted in industrial environments. Although the evidence cited was inconclusive, there was some indication that noise tended to affect work output, speed of work, and certain physiological processes. Individual differences in susceptibility to the ill-effects of noise were also noted. Despite the conclusions that noise detracts from efficiency and well-being under many circumstances, the results of the studies reported are inadequate for the formulation of positive noise effects or general performance trends.

In 1950 Kryter (39) prepared a comprehensive monograph on the research related to the effects of noise on man. The report was

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[1] Underlined parenthetical numbers refer to the numbered references in the bibliography of this report.

divided into three major sections: (1) effects of noise on behavior, (2) deafening effects of noise, and (3) effects of noise on speech communication. In his conclusions on the effects of noise on behavior, the author maintained that the literature reviewed did not support the notion that noise is deleterious to work output or psychomotor performance. His analysis stressed the following points:

1. Most studies reporting detrimental effects of noise on work output are subject to criticism due to poor experimental techniques and uncontrolled variables.

2. Experiments conducted with adequate controls indicate that steady or expected noises do not adversely affect psychomotor activity to a significant degree.

3. Psychological and physiological adaptation and, perhaps, increased effort on the part of the subjects can account to a large extent for the general ineffectiveness of noise on work output and psychomotor performance.

4. Most studies conducted in this problem area have been confined to non-auditory work tasks, thereby neglecting the important factor of required communication and minimizing the effects of noise on performance.

With respect to the other effects of noise on man, the evidence presented in the monograph supported the conclusion that noise is a significant factor in the development of hearing disorders and in the production of interference effects in speech communication. These problems, however, are not the concern of the present report.

SECTION II

PURPOSE OF RESEARCH PROGRAM

While a considerable number of research projects have been undertaken during the past few years to determine the effects of noise on the mental and motor functions of man, the data currently on hand are to some extent still contradictory and incomplete. Further, it is evident from the existing literature that despite the lack of statistically significant differences between/among groups in studies on noise effects, some individuals do exhibit marked changes in performance, physiological activity, and/or emotional attitude when exposed to high intensity sound stimulation. Since these effects have been experimentally demonstrated, additional research might well provide a basis for the explanation of these individual differences.

Broadly stated, the general purpose of the present program of research was two-fold: (1) to determine the effects of high intensity noise on human performance as measured by standard mental tests and learning tasks, and (2) to investigate certain physiological and psychological characteristics with respect to individual differences in noise susceptibility. While it was recognized that complete answers could not be given to the many perplexing problems in the field of noise and human behavior, it was believed that any results obtained from the conduct of rigid experimental research would serve to lessen the existing confusion in the area and provide a basis for a better understanding of sound-behavior relationships.

SECTION III

REVIEW OF STUDIES COMPLETED

INTERMITTENT LOUD NOISE AND MENTAL PERFORMANCE[2]

Abstract. An attempt was made to ascertain the effects of intermittent noise stimulation at an intensity level of 100 db upon human

[2] Summarized from Smith, K. R. Intermittent Loud Noise and Mental Performance. AF Technical Report No. 6368, Wright-Patterson Air Force Base, Ohio. December 1950, 1-8.

performance in two standard mental tests. A pool of 69 subjects was randomized into a control group and an experimental group; the latter group worked under the noise condition. Group comparisons indicated that the effect of the noise was to increase quantity and decrease quality of response, but the differences obtained appeared to be negligible for practical purposes.

Purpose. The purpose of this study was to determine the effect of exposure to intermittent loud noise on mental performance.

Procedure. Two groups of randomly selected individuals were formed from a total sample of 52 male and 17 female adult students at The Pennsylvania State College. Each of these groups worked on the Minnesota Clerical Test[3] and the Minnesota Paper Form Board[4] in accordance with the standard test instructions. A scoring system was imposed which placed a heavy premium on accuracy of response (number of items correct minus twice the number incorrect or omitted). The subjects were further instructed that monetary rewards would be made on the basis of correct responses. The control group (26 male, 8 female) performed under a quiet condition; the experimental group (26 male, 9 female) performed under an intermittent noise condition.

The stimulus intensity in the noise condition was 100 ± 2 db (re 2×10^{-4} rms microbars). The noise spectrum was essentially flat between 100 and 3000 cps, except for a rise of approximately 4 db in the region of 2500 cps. Beginning at 3000 cps, the sound level started a terminal drop of about 12 db per octave band. Duration of the noise stimulus was varied in such a manner that the noise-silence ratio was unity; i.e., the total noise time was equal to the total silent time. The bursts of noise ranged in duration between 10 sec. and 50 sec., and were administered at irregular and unpredictable intervals.[5]

Results and conclusions. The principal data obtained in this study are presented in Figs. 1 and 2. Fig. 1 compares the mean scores of

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[3] This test consists of two subtests: one of these requires the subject to discriminate between pairs of identical numbers and pairs of slightly dissimilar numbers (number-checking); the other requires a similar discrimination between pairs of names (name-checking).

[4] This test calls upon the subject to identify the result of assembling a given group of isolated plane figures.

[5] Details of stimulus production and measurement appear in Appendix I of this report.

the experimental group with those of the control group Each test was scored in four dimensions: (1) number of items attempted, including items omitted, (2) number of items correct, (3) number of items incorrect or omitted, and (4) percentage of attempted items correct. Fig. 2 contains the standard deviations associated with each of the mean scores of Fig. 1.

The differences in mean performance revealed by Fig. 1 were

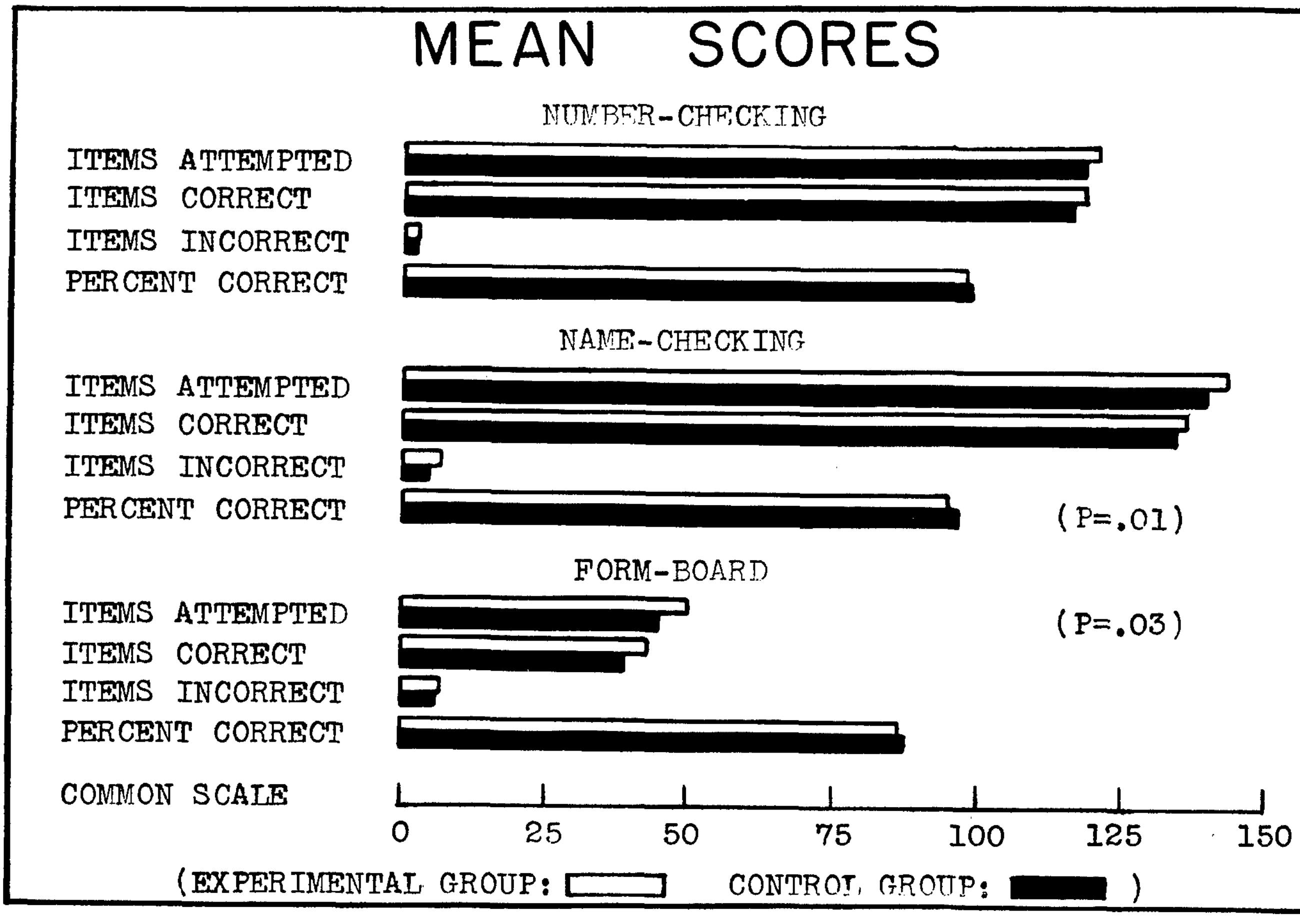

Fig. 1. Comparison of mean scores for experimental group (N=35) and control group (N=34) on all mental tests.

quite consistent. In each test the experimental group attempted more items, scored more items correctly, and scored more items incorrectly; at the same time the experimental group invariably fell behind the control group with respect to accuracy. Two of the differences achieved conventional levels of statistical significance, and the P-value for each of these differences is noted. One (form-board, items attempted) was

significant at the 3% level of confidence; another (name-checking, percent correct) at the 1% level. Evidently the extraneous noise tended to encourage productivity but to discourage accuracy. The question remained as to whether these tendencies were of practical significance as well as statistical.

The variability differences, as shown in Fig. 2, were somewhat

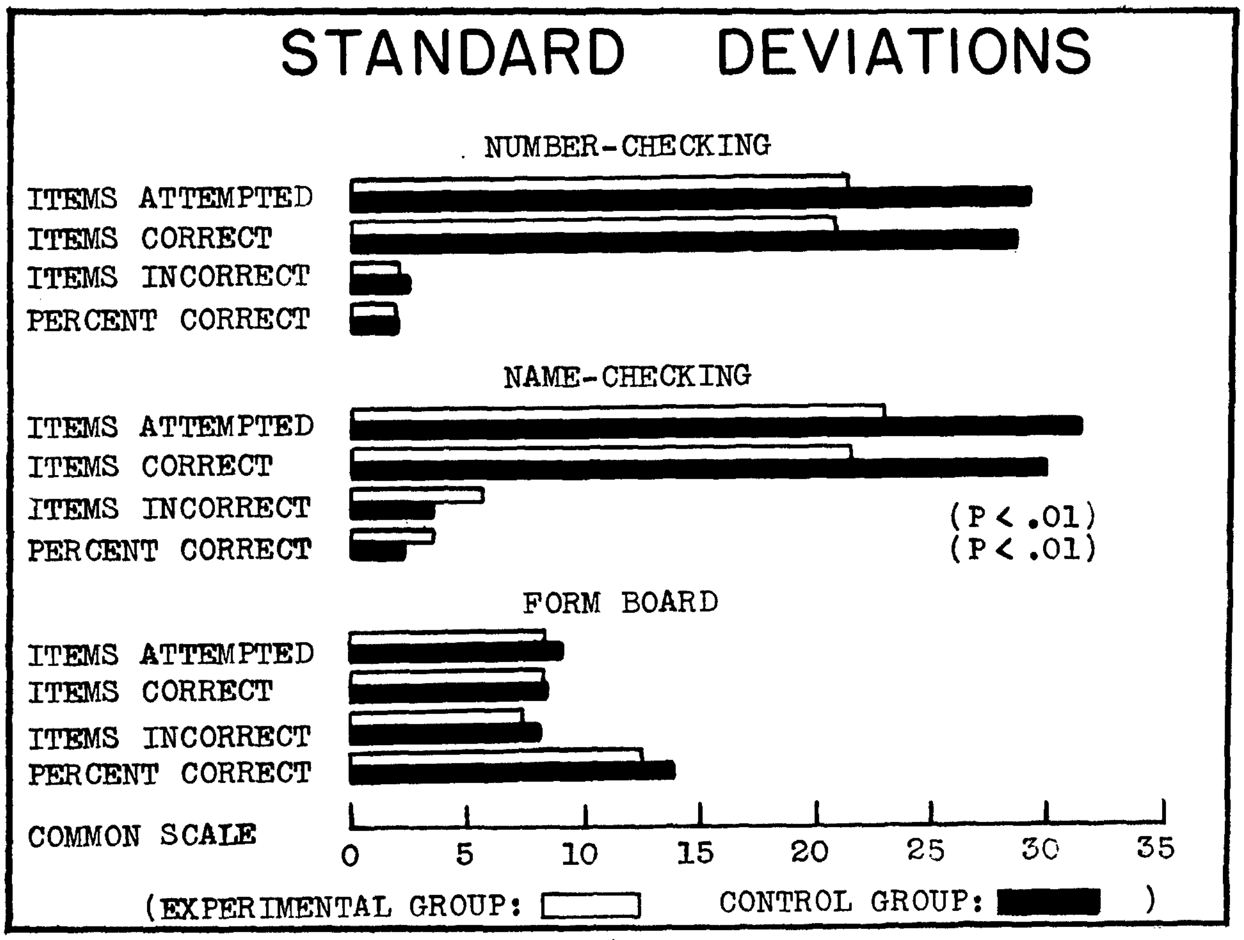

Fig. 2. Comparison of standard deviations associated with mean scores for experimental group (N=35) and control group (N=34) on all mental tests.

more substantial. With two exceptions, the experimental group showed in every case a standard deviation smaller than that of the control group and the differences were sometimes considerable. Statistical analysis revealed, however, that only the two reversals (name-checking, items incorrect and percent correct) achieved statistical significance. The only reliable indication, then, appeared to be that the stimulus produced in one task an increment of variability in number of unacceptable responses and in overall accuracy.

Summary statement. It was found that the effect of bursts of intense noise upon short-term mental performance was to increase the quantity and decrease the quality of response, but these effects were of such magnitude as to suggest practical negligibility.[6] It was suggested that the allegedly malignant effects of extraneous noise might be found primarily in terms of depreciation in sustained performance, or of interference with functions other than adequate output.

INDIVIDUAL DIFFERENCES UNDER THE STRESS OF HIGH INTENSITY NOISE[7]

Abstract. Sixty male subjects were administered the California Capacity Questionnaire under quiet and under 105 db noise to determine the effects of high intensity sound on mental functional capacity. Results of the tests indicated that mental capacity was not affected by noise exposure. The 16 subjects showing the greatest gain and the 16 subjects showing the greatest loss in performance under noise were then compared with reference to five physiological measures obtained prior to noise exposure: (1) systolic blood pressure, (2)diastolic blood pressure, (3) pulse pressure, (4) pulse rate, and (5) respiration rate. Analysis of the data revealed that only the difference in pulse pressure was statistically significant, although the means of the "gain" group tended to be larger than the means of the "loss" group. Comparison of two other groups selected according to subjective reactions following noise exposure ("non-disturbed" group, 21 subjects; "somatic" group, 16 subjects) showed a statistically significant difference only in pulse rate. However, the "somatic" group yielded larger means for all five physiological measures and greater losses in intelligence test scores under noise than did the "non-disturbed" group.

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6 Analysis of results for the male subjects alone, as a particularly homogeneous group, supported the same conclusions.

7 Summarized from Stambaugh, Jr., C. J. An Investigation of Certain Individual Differences under the Stress of High Intensity Sound. Unpublished Ph.D. dissertation. The Pennsylvania State College. June 1950, 1-69.

Purpose. The purposes of this study were: (1) to determine the effects of exposure to high intensity noise on intelligence test performance; (2) to establish the existence of individual differences in noise susceptibility; and (3) to relate any obtained individual differences to the level of activity of the autonomic nervous system.

Procedure. From the roster of the AF ROTC trainees at The Pennsylvania State College, 86 names were chosen at random. No individual was retained in the group who was known to have had a history of otitis media, thickening of the tympanic membrane, otosclerosis, or other diseases or abnormalities of the ear. The final experimental group consisted of 60 male subjects, ages 18 to 24 years, chosen from the original group on the basis of availability of time and ease in scheduling.

The measures obtained in this study were of three types: (1) psychological measures of composite mental ability as indicated by the California Capacity Questionnaire (Forms A and B); (2) physiological measures of the functional level of the autonomic nervous system as revealed by (a) systolic blood pressure, (b) diastolic blood pressure, (c) pulse pressure, (d) pulse rate, and (e) respiration rate; and (3) subjective measures of the disturbing effects of noise as provided by a 27 item reaction check list.[8]

The noise generator employed in the study was designed after that used by Stevens (63). Four loudspeakers (one Western Electric 728B, two Jensen type Q8P, and one Western Electric D-173270) were activated by the noise generated in a gas triode circuit and amplified by a Western Electric type 142B power amplifier. The overall sound level inside the test chamber as measured by an H. H. Scott type 410-A sound level meter ("flat" weighting) was 105 ± 1 db. The noise spectrum in terms of an arbitrary reference level was approximately as follows:

Frequency (cps)	Intensity (db ± 6)
100 - 800	0
800 - 3,000	6
3,000 - 6,000	2
6,000 - 10,000	gradual drop to -18

[8] This list is reproduced in Appendix II.

Fig. 3 shows the apparatus used for the generation and measurement of the noise stimulus. The apparatus was located outside the testing chamber.

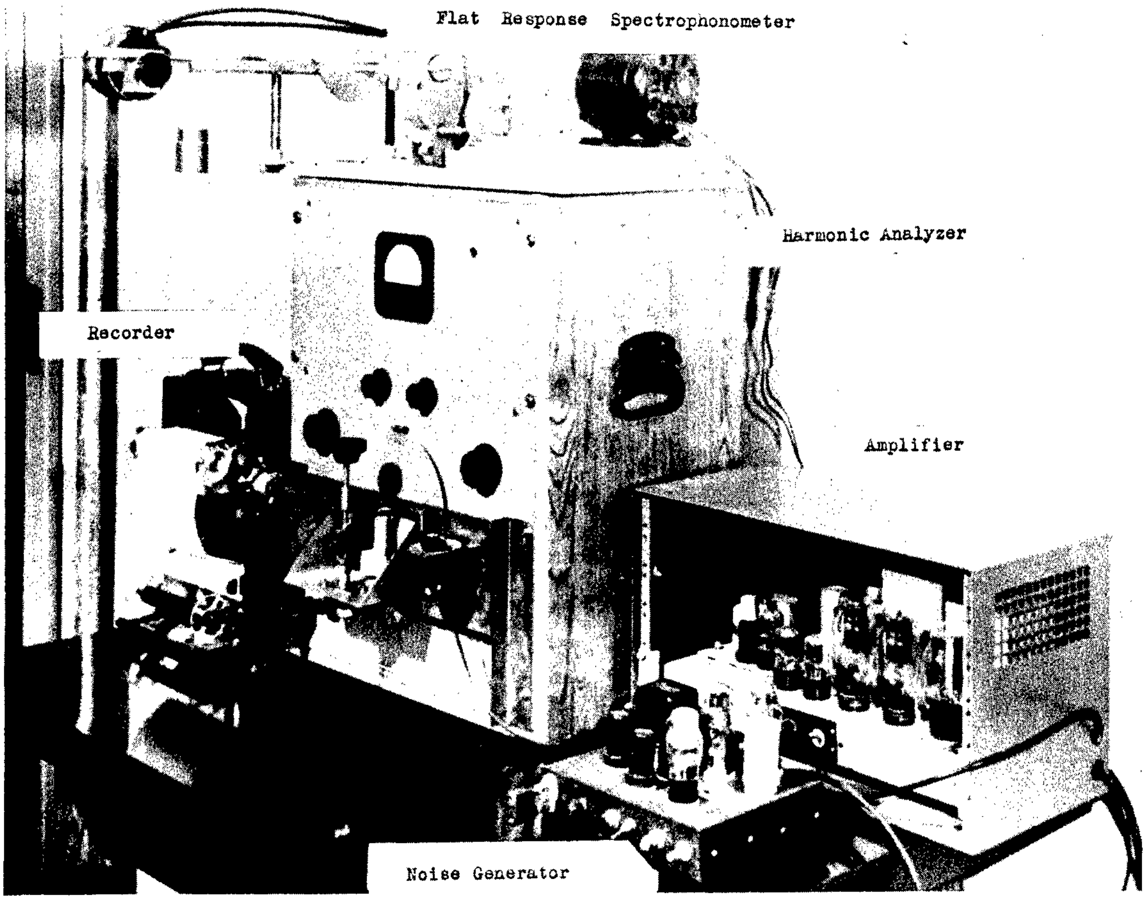

Fig. 3. Noise generating and analyzing equipment.

Two testing sessions of approximately 50 minutes each were required to collect the experimental data. The subjects were tested in groups of two, three, or four with 24 hours elapsing between the first and second testing sessions. In order to minimize practice effects and time errors, the orders of presentation of both noise-quiet sessions and test Forms A-B were alternated in a systematic manner. Table 1 presents the experimental plan employed.

TABLE 1

EXPERIMENTAL PLAN SHOWING ALTERNATION OF NOISE-QUIET CONDITIONS AND ALTERNATION OF A-B TEST FORMS

Session I			Session II		
Condition	Test-Form	No. of Subjects	Condition	Test Form	No. of Subjects
Noise	A	16	Quiet	B	16
Quiet	A	15	Noise	B	15
Noise	B	14	Quiet	A	14
Quiet	B	15	Noise	A	15
Totals		60			60

All physiological measurements were taken prior to noise exposure and all subjects were instructed as to the particular experimental condition (noise or quiet) under which they were to work at each testing session. A 30-min. period was then allowed for the completion of the California Capacity Questionnaire under the appropriate experimental condition. In the noise condition, an additional 3-min. period was allowed for filling in the reaction check list.[9]

[9] The instructions to the subjects (Session I, Noise Condition, Test Form A) are presented in Appendix III. These instructions were appropriately modified to satisfy the requirements of the other test conditions.

Results and conclusions.

(1) Noise vs. quiet test scores. In order to determine the relationship between test performance under the conditions of noise and quiet, the scores obtained on the two similar (though not identical) test forms administered under the two conditions were compared. To provide an adequate basis for the comparison, inter-test differences were canceled out by the alternate presentation of the two test forms in the experimental design. Further corrections were made for regression and practice effects.

The computed correlation coefficient between the 60 scores on the California Capacity Questionnaire for Session I and Session II was 0.66. For Session I, the mean test score was 125.22 and the standard deviation, 14.04; for Session II, the mean test score was 133.33 and the standard deviation, 13.94. Using these values, a regression equation was set up and predicted scores were calculated for Session II. For each individual, the difference between the predicted score and the actual score (Session II) was determined and translated into a gain or loss in performance under noise. The results showed that of the subjects tested under the conditions of the experiment, 30 subjects gained in performance under noise (M = 7.28 points) and 30 subjects lost under noise (M = 8.15 points). It was concluded that noise had no significant effect on mental performance as measured by the California Capacity Questionnaire.

(2) Physiological measurements. On the basis of the scores obtained on the California Capacity Questionnaire, the 16 subjects showing the greatest gain under noise and the 16 subjects showing the greatest loss under noise were selected to form an "up" group and a "down" group, respectively. For each group, the means of the five physiological measures (systolic blood pressure, diastolic blood pressure, pulse pressure, pulse rate, and respiration rate) were computed. Tests of significance of the differences in obtained means for the two groups were performed by analysis of variance, covariance method. The results of the analysis are presented in Table 2.

Inspection of Table 2 shows that a significant difference in mean performance was obtained only with respect to pulse pressure. However, in all cases the means of the "down" group were larger than the means of the "up" group, with the F-ratio for systolic pressure and respiration rate approaching the 5% criterion level of significance.

TABLE 2

LEVELS OF SIGNIFICANCE OF DIFFERENCES BETWEEN PHYSIOLOGICAL MEANS FOR "DOWN" AND "UP" GROUPS

	"Down" Group	"Up" Group	Diff. Between Means	F-Ratio	Level of Significance of Difference
Mean Systolic Pressure	121.31	116.38	4.93	2.38	Approx. 10%
Mean Diastolic Pressure	79.13	78.41	0.72	0.57	Approx. 50%
Mean Pulse Pressure	42.19	37.97	4.22	7.10	Approx. 1.5%
Mean Pulse Rate	80.44	76.98	3.46	1.41	Approx. 25%
Mean Respiration Rate	16.32	13.88	2.44	3.29	Approx. 8%

(3) Reaction check list. Two further groups were formed on the basis of the responses made to the reaction check list. Those individuals who checked one or more items considered as indicating somatic disturbance[10] were included in the "somatic" group; those individuals who checked none of the "somatic" items and no "questionable" items, but only items which were considered as indicating no disturbance were included in the "non-disturbed" group. There were 21 subjects in the "non-disturbed" group and 16 in the "somatic" group. Means of the five physiological measures were computed for each group and the differences between means were tested for significance by analysis of variance, covariance method. Although all means of the "somatic" group were larger than those of the "non-disturbed" group, only the pulse rate difference was statistically significant. The results of the analysis are summarized in Table 3.

[10] See Appendix II for classification of items according to response categories.

TABLE 3

LEVELS OF SIGNIFICANCE OF DIFFERENCES BETWEEN PHYSIOLOGICAL MEANS FOR "SOMATIC" AND "NON-DISTURBED" GROUPS

	"Somatic" Group	"Non-Disturbed" Group	Diff. Between Means	F-Ratio	Level of Significance of Difference
Mean Systolic Pressure	119.25	115.29	3.96	1.96	Approx. 20%
Mean Diastolic Pressure	78.06	76.52	1.54	0.37	Less than 50%
Mean Pulse Pressure	41.19	38.76	2.43	2.27	Approx. 12%
Mean Pulse Rate	78.44	72.19	6.25	5.52	Approx. 2.5%
Mean Respiration Rate	15.94	15.31	0.63	0.31	Less than 50%

Comparison of the "somatic" and "non-disturbed" groups with respect to gain or loss in performance on the California Capacity Questionnaire showed that the "non-disturbed" group gained under noise (M = 1.37 points), while the "somatic" group lost under noise (M = 4.92 points). This difference was significant at the 5% level of confidence. The results of the analysis of variance are presented in Table 4.

<u>Summary statement.</u> The following points were stressed as applying to the experimental group in this study:

(1) The mental functional capacity of the group, as measured by performance on a standardized intelligence test, was not affected by exposure to noise at an intensity level of 105 ± 1 db.

(2) Within the group, individuals differed with respect to the effects of noise on mental performance.

TABLE 4

ANALYSIS OF VARIANCE BETWEEN "SOMATIC" AND "NON-DISTURBED" GROUPS WITH REFERENCE TO GAIN OR LOSS ON INTELLIGENCE TEST PERFORMANCE UNDER NOISE

Source of Variability	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio
Between Groups	1	359.63	359.63	4.15*
Within Groups	35	3034.55	86.70	
Total	36	3394.18		

* Significant at the 5% level.

(3) Those individuals who appeared to be adversely affected by noise showed a tendency to have a slightly higher level of autonomic activity than those not adversely affected.

(4) Those individuals who reported somatic disturbance under noise showed a tendency to have a slightly higher level of autonomic activity than those reporting no disturbance.

(5) Those individuals reporting somatic disturbance appeared to differ from those not reporting disturbance in that they had a greater tendency to be adversely affected by noise in mental performance.

PERSONALITY CHARACTERISTICS UNDER THE STRESS OF HIGH INTENSITY NOISE[11]

Abstract. Sixty male subjects served in a study to determine whether individuals who complained about high intensity noise effects

[11] Summarized from Barrett, A. M. Personality Characteristics under the Stress of High Intensity Sound. Unpublished Ph.D. dissertation. The Pennsylvania State College, June 1950, 1-85.

differed in personality makeup from those who did not. A secondary purpose was to investigate the effects of noise on abstract thinking as measured by the California Capacity Questionnaire. Prior to performance testing, each individual was tested for normal hearing and was given the Minnesota Multiphasic Personality Inventory (MMPI). In addition, five physiological measures were taken (systolic blood pressure, diastolic blood pressure, pulse pressure, pulse rate, and respiration rate). During the last three minutes of noise exposure, subjects completed a check list intended to reveal psychological reactions to noise stress. From 13 to 48 hours after noise exposure, threshold measures were again taken. Results obtained from the intelligence test indicated that noise had no effect on abstract thinking. Scores on the MMPI did not discriminate to any great extent between "non-disturbed" and "somatic" groups (formed on the basis of the subjective reactions to noise stress), although the "somatic" group made significantly lower scores on the California Capacity Questionnaire. In general, the "somatic" group was described as possessing a psychopathic and psychasthenic trend, while the "non-disturbed" group was described as "just plain normal". Further analysis revealed that those subjects whose performance scores increased under noise were "normal", while those whose performance scores decreased under noise showed a significant paranoid trend on the MMPI scale. Post-exposure audiograms revealed hearing losses as great as 30 db between 2000 and 6000 cps.

Purpose.[12] The primary purpose of this study was to investigate the relationship between personality characteristics and (1) subjective complaints and (2) mental performance under the stress of high intensity noise.

Procedure. The subjects, noise stimulus, experimental design, and procedure used in this study were those reported in the summary of Stambaugh's work in the preceding section, with the exception that audiometric tests and the MMPI were administered prior to the measurement of the five physiological indices. Further, audiometric tests were repeated following noise exposure.

Results and conclusions.

(1) Noise vs. quiet test scores. For the 60 subjects, the following scores were obtained on the California Capacity Questionnaire: (1) for quiet, the mean was 120.58 and the standard deviation, 14.52; (2) for noise, the mean was 128.96 and the standard deviation, 14.53. Although

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[12] Since this study was conducted in conjunction with that of Stambaugh (see p. 7), overlapping material has been purposely omitted in this summary and emphasis placed on the investigation of personality characteristics.

the means were not significantly different, the effects of all the experimental variables involved in the study were tested for significance by the Latin Square analysis of variance technique suggested by Grant (28). The summary of this analysis is presented in Table 5. Only the variables of session, test form, and subjects achieved significance at or beyond the 5% level.

TABLE 5

SUMMARY OF ANALYSIS OF VARIANCE FOR ALL EXPERIMENTAL VARIABLES

Source of Variability	DF	Sum of Squares	Mean Square	F-Ratio	Level of Significance
Noise	1	11.40	11.40	<1.00	Non-Sig.
Session	1	1976.40	1976.40	31.48	1%
Form	1	323.40	323.40	5.15	5%
Order	1	5.20	5.20	<1.00	Non-Sig.
Subjects	58	19572.10	337.45	5.37	1%
Error	57	3579.03	62.79		
Total	119	25467.53			

(2) "Somatic" vs. "non-disturbed" group.[13] Comparison of the net scores (differences between retest scores on the California Capacity Questionnaire and scores predicted from original test after corrections were made for regression and practice effects) of the "somatic" and "non-disturbed" groups are presented in Table 6. The data indicated that the "somatic" group did poorer under noise, while the "non-disturbed" group did better. The difference between means (6.34) was significant at the 5% level of confidence with a t-ratio of 1.96.

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[13] See summary of Stambaugh's study in preceding section (p. 12) for the procedure used in forming these two groups.

TABLE 6

COMPARISON OF DIFFERENCE BETWEEN
CALIFORNIA CAPACITY QUESTIONNAIRE SCORE MEANS
FOR "SOMATIC" AND "NON-DISTURBED" GROUPS

	Total N	Ave. Net Score Gain Under Noise	Ave. Net Score Loss Under Noise	Actual Mean of Net Scores	t-Ratio	Level of Significance
"Somatic"	16	+1.99 (N=7)	-6.92 (N=9)	-4.93	1.96	5%
"Non-Disturbed"	21	+3.22 (N=11)	-1.81 (N=10)	+1.41		

An analysis of the personality characteristics of each individual in the "somatic" and "non-disturbed" groups was then performed on the basis of the scores obtained on the various scales of the MMPI. Table 7 presents the T-score means of the several MMPI scales for each group. Computation of t-ratios based on raw scores indicated that no difference between means reached statistical significance.

In an effort to obtain a better personality description of the two groups, an item analysis was performed on the 566 items of the MMPI using the chi-square test (48). Since all items on the MMPI were scored either true or false (with only a few items omitted), only the true items for each group were totaled. When the chi-square value (four-fold table) was significant at or beyond the 10% level after correction by Yate's factor when the cell entry was less than five, the item was accepted as a discriminating one. By this procedure forty-two items were found to differentiate between the "somatic" and "non-disturbed" groups. An analysis of these items indicated on the basis of face validity that individuals of the "somatic" group were on the whole somewhat insecure, inhibited, self-conscious, lacking in confidence, introverted, slightly asocial, and tended toward phobias; the "non-disturbed" group was described as normal.

TABLE 7

COMPARISON OF MINNESOTA MULTIPHASIC PERSONALITY INVENTORY SCALE MEANS FOR "SOMATIC" AND "NON-DISTURBED" GROUPS

Scales*	Hs	D	Hy	Pd	Mf	Pa	Pt	Sc	Ma
"Somatic"	49.50	53.12	54.56	60.56	57.93	54.18	59.87	58.81	59.68
"Non-Disturbed"	51.71	49.95	54.80	55.57	58.04	52.23	54.85	55.62	61.23
t-ratio	1.24	0.61	0.47	1.48	0.05	0.57	1.37	0.82	0.18
Significance	22%	54%	64%	14%	96%	57%	17%	41%	86%

* Scales are coded as follows: Hs-hypochondriasis, D-depression, Hy-hysteria, Pd-psychopathic deviate, Mf-interest, Pa-paranoia, Pt-psychasthenia, Sc-schizophrenia, Ma-hypomania.

(3) "Up" vs. "down" group.[14] A further analysis of personality characteristics was performed for those individuals in the "up" and "down" groups. Table 8 presents the T-score means of the various MMPI scales for the two groups. Comparison of the groups on the basis of t-ratios computed from raw scores revealed no significant differences between means, except for the paranoid (Pa) scale in which the t-ratio closely approached a 5% level of confidence. It was concluded that individuals in the group whose scores decreased under noise ("down" group) were characterized by having a paranoid personality trend; the group in which individual scores increased under noise ("up" group) apparently had normal tendencies.

Comparison of the "up" and "down" groups on the basis of chi-square item analysis also supported this conclusion. The individuals in the "down" group were more disturbed psychologically, with such items as seeing visions, possessing peculiar and strange thoughts, smelling odd

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[14] See summary of Stambaugh's study in preceding section (p. 11) for the procedure used in forming these two groups.

TABLE 8

COMPARISON OF MINNESOTA MULTIPHASIC PERSONALITY INVENTORY SCALE MEANS FOR "UP" AND "DOWN" GROUPS

Scales*	Hs	D	Hy	Pd	Mf	Pa	Pt	Sc	Ma
"Up" Group	50.00	53.12	52.93	54.75	56.31	50.25	55.00	53.87	67.68
"Down" Group	48.25	47.62	52.37	57.25	55.75	53.87	55.81	57.00	60.12
t-ratio	1.30	1.29	0.54	0.35	0.52	1.94	0.23	0.99	0.58
Significance	20%	20%	59%	73%	61%	5%	81%	32%	78%

* See footnote, Table 7 for scale abbreviations.

odors, worrying, etc. appearing significantly more often than in the "up" group. It appeared that the "down" group exhibited personality characteristics that might be termed as inferior, lacking in confidence, worrisome, different, or odd, whereas the "up" group was more nearly normal.

(4) Relationship between "somatic" and "down" groups. Since the "down" group and the "somatic" group appeared disturbed in personality characteristics in somewhat the same direction, a chi-square test was run to determine whether the two groups were independent. Table 9 provided the basic data for the test. The chi-square value obtained was 4.10 which was significant at the 5% level of confidence. It was concluded that a real and meaningful relationship existed between the "down" and "somatic" groups.

(5) Audiometer tests. Prior to performance testing under the conditions of this experiment, all 60 subjects were tested for normal hearing with a Maico D-5 audiometer. No significant deviations from normality were noted in the audiograms obtained. After 33 minutes of 105 db noise stimulation, threshold measurements for 47 subjects were again made, with the time of delay from exposure to retest varying from 13 to 48 hours. Table 10, reproduced in the form of an audiogram,

TABLE 9

NUMBER OF SUBJECTS FROM "DOWN" GROUP WHO WERE ALSO FOUND IN "SOMATIC" AND "NON-DISTURBED" GROUPS

Group	"Down"	"Up" or Otherwise
"Somatic"	7	9
"Non-Disturbed"	2	19

TABLE 10

DISTRIBUTION OF INDIVIDUALS* ON POST-AUDIOMETRIC TESTS

Ave. Loss In Db for both ears	Frequency (cps)									
	128	256	512	1024	2048	2896	4096	5792	8192	11584
0-10	47	47	47	47	41	35	34	39	44	47
11-20					4	10	7	3	3	
21-30					2	2	6	5		
31-40										
41-50										

*N = 47

shows the total number of individuals whose post audiograms revealed the particular db hearing loss for each designated frequency. Losses from 10 to 30 db were obtained for most subjects tested from 13 to 23 hours after exposure, with the losses occurring primarily between 2000 and 6000 cps. In general, the results obtained were in agreement with the results of previous studies on stimulation deafness.

Summary statement. The following points were stressed as findings in this study:

(1) Abstract thinking as measured by the California Capacity Questionnaire was not affected by a 30-min. noise exposure period with the noise at an intensity level of 105 $\pm$ 1db.

(2) Scale scores on the MMPI did not discriminate to any extent between those individuals who complained of somatic disturbances and those who did not. In general, the "somatic" (complaining) group had a psychopathic and psychasthenic trend.

(3) Item analysis of the MMPI revealed that the "somatic" group possessed the traits of insecurity, inhibition, self-consciousness, lack of confidence, introversion, slight asocial trend, and tendency toward phobias. The "non-disturbed" group was described as gregarious, sociable, or "just plain normal".

(4) Those individuals who performed better under noise than under quiet ("up" group) appeared to be normal on the MMPI scales; those individuals who performed worse under noise than under quiet ("down" group) revealed a significant paranoid trend on the MMPI scales. On the basis of item analysis, the "down" group was characterized as inferior, lacking in confidence, worrisome, different or odd.

(5) Significantly more individuals from the "down" group than from the "up" group were found in the "somatic" group.

(6) The "somatic" (complaining) group made significantly lower scores on the intelligence test than did the "non-disturbed" group under the conditions of the experiment.

INTERFERENCE EFFECTS OF HIGH INTENSITY NOISE ON THE RETENTION OF VISUALLY AND AUDITORILY LEARNED MATERIAL[15]

Abstract. Forty-eight subjects were tested to determine the effects of high intensity noise (111 $\pm$ 1 db) on the recall of verbal material learned by means of visual and auditory stimulation. Three types of material were employed in the learning tasks: (1) equivalent lists of 15 meaningful, one syllable, four-letter words; (2) equivalent lists of 15 meaningful statements containing military aviation terms and situations; and (3) equivalent lists of ten dial settings involving a series of numbers between 1 and 100, inclusive, drawn at random. No noise was present during the acquisition trials. Following acquisition, all individuals were subjected to a 30-min. retention period of controlled activity in which sound motion pictures were shown. Recall tests were then administered under conditions of noise and quiet for each of the two learning procedures (visual and auditory). Results of the study showed that high intensity noise had no significant effect on mental performance as measured by recall of verbal material. Further, the combined recall scores (disregarding acquisition procedures) indicated that noise did not significantly affect variability of performance, total output, or number of errors. Subjective reactions to the noise centered around the usual complaints of irritation, distraction, and general disturbance.

Purpose. The purpose of this study was two-fold: (1) to determine the effects of high intensity noise on the recall of meaningful material and (2) to determine whether or not high intensity noise differentially affected the recall of meaningful material learned by means of visual and auditory stimulation.

Procedure. From a total of 110 volunteers from the AF ROTC at The Pennsylvania State College, 48 male students were selected to serve in this study. All subjects possessed normal hearing[16] and were selected at random from a larger group of 62 individuals who passed the hearing test. Each subject served for a total of five one-hour experimental sessions.

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[15] Summarized from Miller, H. G. A Study of the Interference Effects of High Intensity Sound on the Retention of Visually and Auditorially Learned Material. Unpublished Ph.D. dissertation. The Pennsylvania State College. August 1951, 1-83.

[16] Normal hearing was so defined as to include all individuals with a loss no greater than 30 db at any frequency tested by either a Maico D-5 or E-1 audiometer.

The noise source[17] used in this study was that described in the summary of Stambaugh's work in a preceding section of this report. Noise spectra were practically identical, with the exception that in this case the overall noise intensity, as measured by an H. H. Scott 410-A sound level meter, was 111 $\pm$ 1 db (re 0.0002 dyne/cm^2).

Three learning tasks were employed. Task I consisted of lists of 15 meaningful, one syllable, four-letter words drawn from the list of 1000 words occurring most frequently in the English language (64). Five lists were constructed, each phonetically equivalent according to the alphabet of the International Phonetic Association (69) and each checked for the relative frequency of occurrence of speech sounds for university adults (65). No word was used in more than one list and all words for which homonyms existed were eliminated. When the words for each list were made up, the order of occurrence in the list was determined by using a table of random numbers.[18] Task II consisted of lists of 15 meaningful statements, each statement varying in length from six to ten words and occupying from 3.5 to 5.0 sec. oral reading time. The content of the statements was drawn from military aviation situations. Although all statements were meaningful and complete, there were no statements of fact answerable on the basis of previous knowledge. Five lists were constructed,[19] each comparable to the others with respect to content and composition. Task III involved the learning of a series of dial settings corresponding to a series of numbers between 1 and 100, inclusive. Five lists of dial settings were prepared,[20] each list containing a series of ten numbers drawn from a table of random numbers. No number occurred more than once in the five lists. Ten different dials were used; eight were single color coded[21] (red, yellow, blue, gray, orange, white, black, green) and two were double color coded (red and yellow, black and white).

The first phase of the experimental procedure consisted of a familiarization process in which all subjects were acquainted with all aspects of

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[17] See summary of Stambaugh's study in preceding section (p. 8) for a description of the apparatus and specification of the noise spectrum.

[18] The lists are reproduced in Appendix IV.

[19] The lists are reproduced in Appendix V.

[20] The lists are reproduced in Appendix VI.

[21] All subjects were originally screened for color blindness.

the experiment. One of the five equivalent forms for each task was used during this period, and all subjects were given experience with visual and auditory presentations of the tasks, with quiet and noise conditions present in the retention tests.

In the experiment proper four conditions were employed and may be represented as follows:

Condition	Training	Interpolated Activity	Test
1	Auditory	Sound motion picture	Noise
2	Visual	Sound motion picture	Noise
3	Auditory	Sound motion picture	Quiet
4	Visual	Sound motion picture	Quiet

The order of presentation of the conditions was counterbalanced to minimize serial effects of practice, fatigue, and interaction. Since there were 24 possible combinations of order for the four equivalent forms of a given task under the four experimental conditions, two subjects were assigned to each of these combinations. The same two subjects served together in all conditions of the experiment. Learning and retention was conducted with one pair of subjects at a time; no fewer than three nor more than five days elapsed between consecutive sessions. At the end of the fourth session, all subjects filled out a questionnaire in which they described their estimate of the effects of noise on recall and their general reactions to the noise stimulus.

In the training period, visual presentation of the lists of Task I was accomplished by means of the Hull type memory drum shown in Fig. 4. The exposure time was 3 sec. per item, with three exposures of each list allowed in the learning period. The lists were presented auditorily by means of a Brush BK 414 tape recorder, with intervals and number of exposures identical to those for the visual presentation. The recall test for Task I consisted of requiring the subject to reproduce the list, as learned, on a prepared test blank.

The training period for Task II was the same as that for Task I, with the exception that the exposure interval was 6 sec., instead of 3 sec. The recall test consisted of filling in a blank space substituted for a term containing basic information in the original statement.

The training period for Task III was the same as that described for Task II. In the recall test, however, the subjects were required to set ten dials[22] on the panel shown in Fig. 5 in accordance with the learned settings.

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[22] The centers of all knobs were color coded as previously indicated.

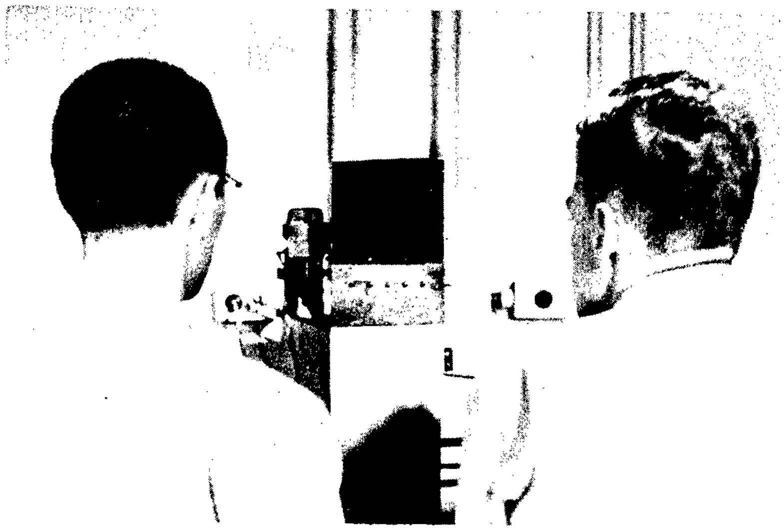

Fig. 4. Manner in which learning tasks were presented visually by means of Hull-type memory drum.

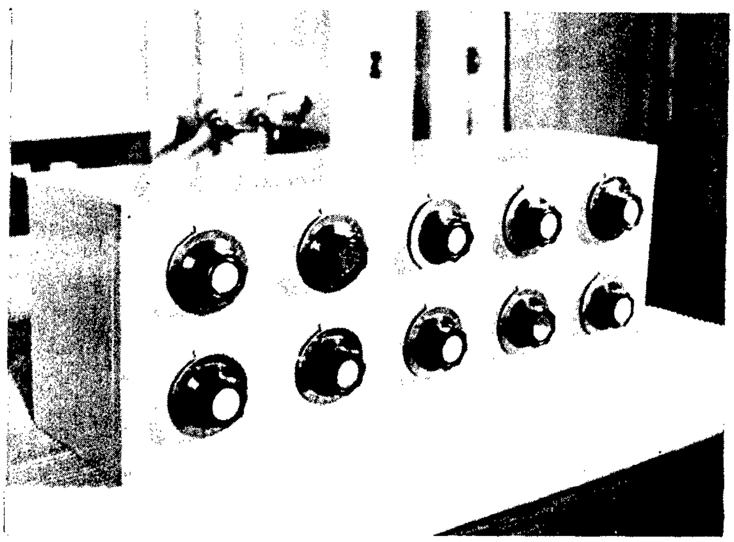

Fig. 5. Dial panel used in testing of Task III.

The period of activity interpolated between acquisition and recall was the same for all subjects. It consisted of a 30-min. retention interval during which one of four U.S. Army training films, or a film on conservation activities, was shown. All films were sound motion pictures; a different film was shown at each period of interpolated activity for a given pair of subjects.

Results and conclusions.

(1) Noise vs. quiet recall scores. The means and standard deviations of the recall scores obtained on Tasks I, II, and III under all experimental conditions are presented in Table 11.

TABLE 11

MEANS AND STANDARD DEVIATIONS FOR RECALL SCORES ON TASKS I, II, AND III AND ALL TASKS COMBINED

Training Procedure:	Visual Presentation		Auditory Presentation	
Test Condition:	Quiet	Noise	Quiet	Noise
Task I				
Mean	9.35	9.42	9.31	9.19
Standard deviation	2.61	3.09	3.32	3.42
Task II				
Mean	9.29	8.77	8.83	9.25
Standard deviation	2.58	2.82	2.90	2.55
Task III				
Mean	6.75	6.58	7.13	6.69
Standard deviation	2.54	2.56	2.56	2.62
All tasks combined				
Mean	25.44	24.77	25.27	25.13
Standard deviation	5.61	6.17	7.07	6.45

An analysis of the performance under noise and under quiet for the three individual tasks and for all tasks combined was made by adding the scores of the two noise conditions and comparing them with the added scores of the two quiet conditions. These data are shown in Table 12. Although all means for recall under noise were slightly smaller than those for recall under quiet, there were no statistically significant differences. It was concluded that noise had no effect on the higher mental processes as measured by the recall of verbal material

TABLE 12

MEANS, DIFFERENCES BETWEEN MEANS, STANDARD ERRORS OF DIFFERENCES, AND TESTS OF SIGNIFICANCE UNDER NOISE AND QUIET CONDITIONS FOR TASKS I, II, AND III AND ALL TASKS COMBINED

	Task I	Task II	Task III	All Tasks Combined
Mean-Quiet	18.67	18.13	13.88	50.71
Mean-Noise	18.60	18.02	13.27	49.90
Loss under Noise	0.34%	0.57%	4.55%	1.60%
Difference between Means	0.07	0.11	0.61	0.81
Standard Error of Difference	0.59	0.47	0.52	0.98
Critical Ratio	0.106	0.224	1.163	0.830
Level of Significance	92%	83%	25%	41%

Table 13 contains the results of the comparisons of group variability under the conditions of noise and quiet as measured by the standard deviations of the distributions obtained on the recall tests for the three tasks of this experiment. In all cases the F-ratios used to evaluate the significance of the differences had a probability of occurrence by chance above the 10% level of confidence. It was concluded that noise had no effect on variability of performance as measured by recall of verbal material.

TABLE 13

STANDARD DEVIATIONS AND TESTS OF SIGNIFICANCE OF DIFFERENCES BETWEEN STANDARD DEVIATIONS FOR NOISE AND QUIET RECALL PERFORMANCE ON TASKS I, II, AND III AND ALL TASKS COMBINED

	Task I	Task II	Task III	All Tasks Combined
Standard Deviation of Quiet	4.83	4.79	4.31	11.37
Standard Deviation for Noise	5.39	4.62	4.36	10.67
F-ratio	1.245	1.075	1.025	1.136
Level of Significance	above 10%	above 10%	above 10%	above 10%

A further analysis was performed to determine whether noise affected (1) production (number of items attempted) or (2) accuracy (number of attempted items incorrect) for the three combined tasks. The data for this analysis are presented in Table 14. Since neither of the obtained differences was statistically significant, it was concluded that noise had no effect on production or accuracy in recall.

TABLE 14

PRODUCTION AND ERROR MEANS AND TESTS
OF SIGNIFICANCE OF DIFFERENCES
OBTAINED UNDER NOISE AND QUIET CONDITIONS

	Mean Noise	Mean Quiet	Difference between Means	Standard Error of Difference	Critical Ratio	Level of Significance
Production	68.54	68.71	0.17	0.54	0.31	76%
Errors	18.65	18.00	0.65	0.84	0.77	45%

(2) Differential effects of noise on visual and auditory learning. In order to test the hypothesis that recall of material learned by auditory stimulation would be adversely affected by the presence of noise to a greater extent than the recall of material learned by visual stimulation, the differences between noise and quiet recall scores for visual learning were compared with the differences between noise and quiet recall scores for auditory learning. The data obtained from this analysis for the three individual tasks and for the three tasks combined revealed no statistically significant differences. Two interpretations were given to these findings: (1) imagery may not have been an important factor in the recall of verbal material, and (2) imagery may have been an important factor in recall, but the noise condition imposed in this study did not operate to interfere with such imagery.

According to the data obtained from a questionnaire, 27 of the 48 subjects reported the use of auditory imagery in their attempts to recall the material learned through auditory stimulation. The performance of these subjects under noise, however, did not show any greater interference than the performance of those subjects not reporting the use of auditory imagery. Fifteen subjects further reported that noise interfered with the recall of auditorily learned material, but an analysis of their scores failed to support this contention.

(3) Subjective reactions to noise stimulus. In response to the check list designed to measure the intensity of subjective reactions to

the noise stimulus, the majority of subjects reported minimal reactions. Table 15 shows the frequency of response to the five degrees of intensity for each of the eight items on the check list. The scores of those subjects reporting more intense reactions to the noise stimulus were evaluated, but no relationship was found between intensity of reaction and performance.

TABLE 15

FREQUENCY OF RESPONSE TO ITEMS ON CHECK LIST INDICATING INTENSITY OF EFFECT UNDER NOISE

Categories of effects	Not at all	A little	Some-what	Quite a bit	A great deal	Total
1. Disturbance	21	22	5	0	0	48
2. Nausea	41	5	0	2	0	48
3. Fright	42	6	0	0	0	48
4. Pain	36	9	2	1	0	48
5. Irritation	30	15	2	1	0	48
6. Distraction	27	17	3	1	0	48
7. Dizziness	45	2	0	0	1	48
8. Nervousness	34	12	2	0	0	48
Total	276	88	14	5	1	384

Summary statement. The following items were emphasized in the conclusions of the study:

(1) Noise of 111 $\pm$ 1 db with an approximately "flat" spectrum up to 6000 cps did not significantly affect the recall of verbal material learned under controlled conditions.

(2) The recall of material learned by means of auditory stimulation was not interfered with by noise to a greater extent than the recall of material learned by visual stimulation.

(3) The noise stimulus employed aroused only minimal subjective reactions with respect to eight psychological and somatic categories of disturbance including irritation, distraction, nervousness, fright, nausea, pain, and dizziness.

(4) Subjective reports indicated that some disturbances due to the noise stimulus were initially present, but adaptation was quickly achieved, with the noise no longer perceived as a noxious stimulus.

EFFECTS OF HIGH INTENSITY NOISE ON CERTAIN PSYCHOLOGICAL VARIABLES[23]

Abstract. One hundred and three subjects served in a study to determine the effects of high intensity noise (103 $\pm$ 1 db) on the following factors: (1) quality and quantity of somatic complaints, (2) intellectual performance, and (3) auditory imagery; further, the relations of personality and "griping" to intellectual performance under noise were investigated and the attempt was made to differentiate subjects on the basis of certain items on the MMPI. The subjects were divided into eight randomly selected groups and served for a total of six one-hour sessions. Analysis of the data revealed that high intensity noise (1) did not affect the number of subjective complaints, but increased their specificity, (2) had no effect on mean intellectual performance, but significantly increased number of errors, and (3) tended to facilitate auditory imagery. No significant relationships were found between mental performance under noise and (1) maladjustment scores on a standard group personality inventory, (2) non-somatic complaining ("griping"), and (3) selected items from the MMPI.

Purpose. This study was designed to investigate the effects of high intensity noise on (1) the quality and quantity of somatic complaints, (2) intellectual performance, and (3) auditory imagery. In addition, the study was directed toward the establishment of relations between intellectual performance under noise and (1) scores on a standard personality inventory,

[23] Summarized from Blau, T. H. Effects of High Intensity Sound on Certain Psychological Variables. Unpublished Ph.D. dissertation. The Pennsylvania State College. June 1951, 1-49.

(2) non-somatic complaints or "gripes", and (3) 24 selected items from the MMPI.

Procedure. The subjects for this experiment were 103 male volunteers from the AF ROTC at The Pennsylvania State College. All were college upperclassmen ranging in age from 19 to 26 years, with a mean of 22 years.

Two experimental conditions were employed: (1) noise[24] (intensity level 103 $\pm$ 2db re. 0.0002 dyne/cm^2) and (2) quiet (ambient noise level in test room 50 $\pm$ 10 db re. 0.0002 dyne/cm^2).

The performance and personality measuring devices used in this study were as follows: (1) the MMPI scale, consisting of twenty-four items found by Barrett[25] to differentiate his "up" group from his "down" group on intellectual performance under noise, (2) the McFarland-Seitz P-S Blank, a group test of maladjustment, (3) the Morse Gripe Scale, an inventory of common complaints dealing with inter-personal dissatisfactions, (4) the Pre-Test and Post-Test Somatic Complaint Scales,[26] an original inventory of 85 somatic complaints intended to evaluate the subjective effects of high intensity noise both before and after noise exposure, (5) the Otis Self-Administering Tests of Mental Ability (four forms of the Otis-Higher series), and (6) the Rhyming Tasks,[27] an original measure consisting of six forms of a rhyming task intended to reveal the effects of high intensity noise on auditory imagery.

A total of six sessions was conducted during the experiment; each session lasted approximately one hour. During sessions I and II, which were introductory in nature, all subjects were administered various pre-tests and preliminary performance tasks. No noise was present during the introductory sessions. Subjects were then equated on the basis of the results on Intermediate Forms A and B of the Otis Test and Introductory Forms 1 and 2 of the Rhymes Task.

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[24] Details of the noise-generating equipment are contained in Appendix VII, with graphical representations of typical noise spectra appearing in Appendix VIII.

[25] See summary of Barrett's study in preceding section (p. 17) for further information on MMPI analysis.

[26] See Appendix IX for the Somatic Complaint Scale and accompanying instructions for Pre-Test and Post-Test.

[27] See Appendix X for one of the rhyming tasks and accompanying instructions.

During each of Sessions III through VI, half of the subjects performed under the high intensity noise condition, while the other half performed under quiet. Each subject worked for two sessions under each of the two experimental conditions. At each noise session a 5-min. adaptation period was allowed before testing began. In all sessions the subjects were allowed 16 minutes to complete one form of the Otis Test and 10 minutes to complete one Rhymes Task. A 3-min. relaxation period separated the two tasks. During the sound sessions, the high intensity noise was turned off one minute after the completion of the last task, with the exception of the final noise exposure at which time the noise remained on while the subjects filled out the Post-Test Complaint Scale. Total noise exposure amounted to two sessions of approximately 40 minutes each for each subject.

Results and conclusions.

(1) Effects of noise on somatic complaints. The Pre-Test and Post-Test Complaint Scales were used to measure somatic complaints before and after exposure to the high intensity noise. The mean number of somatic complaints expressed by subjects before exposure was 2.98, while the mean number of complaints after exposure was 3.20. The critical ratio for the obtained difference between means was found to be 0.67 which was not statistically significant. The standard deviation for complaints on the Pre-Test scale was 2.83, while the standard deviation on the Post-Test was 2.82. This difference was obviously not significant. It was concluded that high intensity noise had no effect on the quantity or variability of somatic complaints.

The items on the Pre-Test and Post-Test Complaint Scales were then rated by a group of five judges with respect to generality or specificity of complaints in order to evaluate the nature of the complaints expressed by the subjects. Generality and specificity ratings were made with reference to anatomical locations and physiological descriptions used in the items. Sixty-two items were agreed upon by four or more judges as to designation[28] and were used in the calculation of Generality:Specificity proportions. For complaints before noise exposure, this proportion was 0.54; for complaints during final exposure, 0.14. The critical ratio for the obtained difference between proportions (6.67) was significant beyond the 1% level of confidence. It was concluded that somatic complaints during normally quiet periods were general with regard to anatomical location and description, but somatic complaints during high intensity noise exposure tended to be specific.

[28] See Appendix IX for the items selected and their judged designations.

(2) Effects of noise on intellectual performance. The performance of each subject on the four forms of the Otis Test administered during the experimental sessions was tabulated to provide a total noise score and a total quiet score, both for number of items correct and number of items incorrect. For the noise conditions, the mean number of correct items was 114.10 and the standard deviation was 16.51; the mean number of incorrect items was 27.87 and the standard deviation, 13.07. For the quiet condition, the mean number of correct items was 114.37 and the standard deviation was 15.69; the mean number of incorrect items was 22.82 and the standard deviation, 11.01. Statistical tests revealed no significant difference in either the obtained means or standard deviations of the correct items on the Otis Tests for the two experimental conditions. For the incorrect items, however, the obtained differences in means and standard deviations were both statistically significant beyond the 1% level of confidence, with critical ratios of 7.43 and 3.22, respectively.

(3) Effects of noise on auditory imagery. The scores of each subject on the Rhymes Task presented during the four experimental sessions were consolidated to provide a total noise score and a total quiet score, both for number of items correct and number of items incorrect. For the noise condition, the mean number of correct rhymes was 63.85 and the standard deviation was 15.88; the mean number of incorrect rhymes was 8.94 and the standard deviation, 10.87. For the quiet condition, the mean number of correct rhymes was 60.91 and the standard deviation was 15.44; the mean number of incorrect rhymes was 7.51 and the standard deviation, 8.64. Statistical tests revealed that significant differences were present in the obtained means for both correct and incorrect rhymes; the critical ratios were 2.75 (significant at the 1% level of confidence) and 1.91 (significant at approximately the 5% level of confidence), respectively. A comparison of the standard deviations for the Rhymes Task correct scores under noise and under quiet showed no significant difference; for incorrect scores, however, a critical ratio of 3.33 (significant beyond the 1% level of confidence) was obtained. It was concluded on the basis of these tests that noise had a significant effect on the rhyming tasks, tending to facilitate auditory imagery.

(4) The personality measures. Table 16 is a summary table of the various personality measures administered in the present study and shows their correlation with each other and with the (noise minus quiet) intelligence test scores. Correlations of 0.20 and 0.26 were required to achieve 5% and 1% levels of significance, respectively. Since none of the measures correlated this highly with the (noise minus

quiet) Otis Test scores, it was concluded that no significant relationships existed between intellectual performance under high intensity noise and (1) scores on the McFarland-Seitz P-S Blank, (2) scores on the Morse Gripe Scale, and (3) scores on the MMPI.

TABLE 16

CORRELATION OF VARIOUS PERSONALITY MEASURES WITH EACH OTHER AND WITH (NOISE MINUS QUIET) INTELLIGENCE TEST SCORES

	MMPI*	P-S Blank	Gripe Scale	Pre-Test Complaint	Post-Test Complaint	Noise minus Quiet (correct) Otis
McFarland-Seitz P-S Blank	0.34					
Noise Gripe Scale	0.06	-0.26				
Pre-Test Complaint Scale	0.20	-0.37	0.03			
Post-Test Complaint Scale	0.09	-0.17	-0.04	0.29		
Sound Minus Quiet (Correct) Otis Tests	-0.04	-0.07	-0.04	-0.20	-0.11	
Sound Minus Quiet (Incorrect) Otis Tests	-0.03	-0.01	0.00	0.00	-0.09	-0.60

* Minnesota Multiphasic Personality Inventory

Summary statement. The conclusions of this study centered about the following major points:

(1) High intensity noise did not affect the number of complaints expressed by subjects, but tended to arouse somatic complaints of specific anatomical location and description.

(2) Exposure to high intensity noise did not affect intellectual performance in the group studied, although the number of errors on the intelligence tests tended to increase under noise.

(3) As measured by a rhyming task, high intensity noise had a significant effect of facilitation of auditory imagery.

(4) No significant relationships were found between intellectual performance under high intensity noise and (a) maladjustment scores on a standard personality inventory, (b) non-somatic complaints or "gripes", and (c) personality characteristcs based on selected items of the MMPI.

INTERFERENCE EFFECTS OF LOUD NOISE ON RETENTION[29]

Abstract. Eighty subjects were divided into four groups of 20 each and tested for retention of rote-learned material under four conditions of quiet and noise (116 db) in a learning-recall experiment. The conditions were as follows: (a) acquisition under noise, recall under noise; (b) acquisition in quiet, recall in quiet; (c) acquisition under noise, recall in quiet; and (d) acquisition in quiet, recall under noise. On the basis of results of analysis of variance,[30] it was concluded that noise did not produce a significant interference effect in the recall of verbal material, although the obtained F-ratio approached the 5% level of confidence. The data obtained supported the results of a previous study.[31]

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[29] Summarized from Kobrick, J. L. The Interference of Loud Noise with Retention. The Pennsylvania State College. May 1950.

[30] In preparing this summary report, the writer has reanalyzed the original data of Kobrick's study in accordance with more generally acceptable statistical procedures. The interpretation of results herein presented is based upon this analysis.

[31] See summary of Miller's study in preceding section (p. 27-28) of this report.

Purpose. The purpose of this study was to determine the effects of noise on the human retention of nonsense syllables with the conditions of quiet and noise in all possible orders in the learning-recall sequence.

Procedure. Eighty male college students, ranging in age from approximately 18 to 25 years, served as subjects. There were no reports of known hearing loss, organic ear abnormalities, or pathological conditions in the group. The experimental task consisted of learning a list of paired nonsense syllables and, after 20 minutes, being tested for retention by recall and recognition methods.

The material used in the learning task consisted of four lists[32] composed of two types of nonsense syllables; (1) the standard nonsense syllable of consonant-vowel-consonant[33] and (2) an original number-letter-number combination. Four different lists of material were prepared, each list containing a total of 20 syllables with 10 nonsense syllables paired respectively with 10 number-letter-number combinations.

A Hull-type memory drum[34] was used to present the lists of words in accordance with the rote-learning technique of paired associates, or the anticipation method. The stimulus element of each pair (number-letter-number) appeared in the left aperature for a period of 7 sec. Five sec. later, the response element of the pair (consonant-vowel-consonant) appeared in the right aperature for 2 sec. Serial presentation of material was used throughout all experimental conditions.

The four conditions used in the study were: (1) acquisition under noise, recall and recognition under noise; (2) acquisition in quiet, recall and recognition in quiet; (3) acquisition under noise, recall and recognition in quiet; and (4) acquisition in quiet, recall and recognition under noise. The temporal order of the four conditions was randomly determined with the restriction that no treatment was repeated until all four had been assigned. This procedure was repeated 20 times to provide four groups of 20 subjects each for the four experimental conditions.

Each subject in each group was assigned by randomization one of the four lists of words to be learned. Fifteen presentations of the

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32 These lists are reproduced in Appendix XI.

33 Selected from Hull's table of nonsense syllables of less than 5% meaningfulness (33).

34 See Fig. 4, p. 25 of this report.

assigned material were provided for each subject in accordance with the conditions of the experimental plan. Each subject recorded his responses on a blank sheet of paper following each presentation. A 20-min. rest period in quiet was then allowed, regardless of experimental group. Following this, the subject returned to the test situation for the measurement of retention under the appropriate quiet or noise condition. Two measures of retention were taken: (1) recall, by writing the response syllable after the designated stimulus, and (2) recognition, by checking one of three alternative response syllables after each stimulus.

The noise stimulus used in this study was provided by essentially the same apparatus as that employed by Miller.[35] The overall noise intensity was measured with an H. H. Scott 410-A hand meter and verified by several other instruments and techniques. The readings obtained were 115 $\pm$ 2 db (re 2 x 10^{-4} rms microbars). Using the method suggested by McGrath (<u>47</u>), the equivalent intensity level of the noise stimulus was computed to be 128 db in the 600-1200 cps octave band (code 16). Computed octave band levels ($\pm$ 2 db) based upon an original integration procedure[36] were as follows:

Frequency (cps)	Sound Level (db)
0 - 75	72
75 - 150	93
150 - 300	95
300 - 600	98
600 - 1,200	98
1,200 - 2,400	109
2,400 - 4,800	114
4,800 - 10,000	106
10,000 - 16,000	94

<u>Results</u> <u>and</u> <u>conclusions</u>. The means and standard deviations of the recall and recognition scores (number of correct responses) obtained for each of the four experimental conditions are presented in Table 17. In all cases, the means of the recognition scores were considerably larger than those for recall, while the standard deviations were considerably smaller. These results are consistent with the findings of other retention studies in which better performance has been evidenced under recognition than under recall.

Following the application of an exact test of the hypothesis of homo-

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[35] See Appendix VII for details of the noise generating unit.

[36] The procedure used was considered valid since the predicted overall noise intensity of 116 $\pm$ 2 db for a square law sound level meter was confirmed by an actual reading of 116 db on a General Radio meter.

TABLE 17

MEANS AND STANDARD DEVIATIONS
OF RECALL AND RECOGNITION SCORES
UNDER FOUR CONDITIONS OF ACQUISITION-RETENTION

CONDITION	RECALL		RECOGNITION	
	Mean	Standard Deviation	Mean	Standard Deviation
I. Acquisition-sound; retention-sound	4.53	2.88	9.74	0.78
II. Acquisition-quiet; retention-quiet	6.55	2.54	9.65	0.73
III. Acquisition-sound; retention-quiet	4.50	2.27	9.85	0.36
IV. Acquisition-quiet retention-sound	4.70	2.17	9.80	0.51

TABLE 18

SUMMARY OF ANALYSIS OF VARIANCE
OF RECALL SCORES OBTAINED UNDER
FOUR CONDITIONS OF ACQUISITION-RETENTION

Source	Sums of Squares	DF	Mean Square	F-ratio*
B/Conditions	58.65	3	19.55	2.69
W/Conditions	484.89	75	7.25	
Total	543.54	78		

* $F_{.05}\ 3,75 = 2.73$

geneity of variance[37] in the obtained recall scores, an analysis of variance produced the results shown in Table 18. Since the computed value of the F-ratio (2.69 with 3 and 75 degrees of freedom) was not statistically significant at the 5% level of confidence, it was concluded that the presence of noise in acquisition and retention did not impair mental performance as measured by the recall of verbal material. Analysis of the recognition data resulted in a similar conclusion.

Summary statement. Results of the present study on the recall of verbal material under the conditions specified were in general agreement with those of previous studies in which noise was found to have no significant effect on mental performance.

SECTION IV

GENERAL CONCLUSIONS

On the basis of the results of the foregoing studies, the following general conclusions appear justified regarding the effects of high intensity noise (100 to 116 db) on human behavior.

NOISE AND MENTAL PERFORMANCE

High intensity noise stimulation has no marked effect upon short-term mental performance as measured by standard intelligence tests, such as the California Capacity Questionnaire and the Otis Self-Administering Tests of Mental Ability. Although random bursts of intense noise may produce statistically significant increases in the quantity and decreases in the quality of responses on certain aptitude tests, such effects are of such small magnitude as to be of questionable practical significance. Further, the presence of high intensity noise does not interfere with the recall of nonsense syllables and meaningful verbal material, regardless of the sound conditions under which the material is learned or the manner (auditory or visual) in which the material is displayed for learning. There is, however, some indication, that noise does facilitate auditory imagery as measured by verbal rhyming tasks.

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[37] Bartlett's test was applied and yielded a chi-square value of 1.35 which, for 3 degrees of freedom, was not significant; hence the hypothesis of homogeneous variance was retained.

PERSONALITY CHARACTERISTICS AND NOISE SUSCEPTIBILITY

Although large individual differences are generally observed in intellectual performance under high intensity noise, no personality characteristic has yet been isolated which permits the successful prediction of human performance under noise stress. At present, it does not appear that the MMPI, the McFarland-Seitz P-S Blank, or the Morse Gripe Scale are valid instruments for differentiating those individuals whose performance is likely to improve under noise from those individuals whose performance is likely to deteriorate under noise. However, since the results of the studies undertaken are somewhat inconsistent, further work along these lines is indicated.

PHYSIOLOGICAL MEASUREMENTS AND NOISE SUSCEPTIBILITY

The data obtained in this series of studies suggests that a relationship exists between intellectual performance under noise and level of activity of the autonomic nervous system as measured by certain physiological indices and/or subjective reactions to intense stimulation. Of the indices investigated, pulse rate and pulse pressure appear to be fairly adequate for differentiating between noise susceptible and non-noise susceptible individuals. Further, the evidence indicates that during intense noise stimulation somatic complaints become more specific in anatomical location and description than those occurring in normally quiet periods. Although the results of this phase of the research program are somewhat more conclusive than the results of the studies on personality characteristics, additional research needs to be conducted before specific relationships may be established.

HEARING LOSS

In general, the findings in this area are in agreement with those of previous studies which have revealed that a temporary hearing loss may be produced by high level noise exposures. The amount of hearing loss is inversely related to the time elapsed between noise exposure and threshold measurement. No permanent injuries to the hearing mechanism were reported following noise stimulation at the levels used in this series of studies.

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APPENDIX I

INSTRUMENTATION OF STUDY ON INTERMITTENT LOUD NOISE AND MENTAL PERFORMANCE

The experimental stimulus utilized in this investigation was generated by a modified Harvard Psycho-Acoustic Laboratory Type 422 noise generator. The current passing continuously between cathode and grid of a conducting 2D21 gas tube was led through a resistor to provide voltage for amplification. The output of the noise generator was led in parallel to (1) a Bogen Model EX-35 amplifier and (2) a Bogen Model E-14 amplifier.

The first amplifier drove in parallel two General Electric 51201D speakers mounted (in conventional cabinets) on the two sidewalls of the auditorium and directed towards its exposure area. The second amplifier supplied power for a single Jensen A-12 PM loudspeaker mounted (in a plywood cabinet) 11 feet above the floor at front-center of the room and directed toward the exposure area.

Sound level measurements on the operating system were made in the empty auditorium and checked during actual experimentation with subjects present. Overall sound pressure was determined at eight points in the exposure area by use of an H. H. Scott 410-A sound level meter ("flat" calibration) and proved to be quite uniform throughout the area at 100 $\pm$ 2 db (re 2 x 10^{-4} rms microbars).

The spectra described in the text of this report were obtained at several points in the exposure area. The transducer employed was an Altec-Lansing 21B condenser microphone, described by the manufacturer as omnidirectional, with an associated P518A power supply. Reciprocity calibration of this microphone against a Western Electric 640AA condenser microphone demonstrated a sensitivity uniform (within $\pm$ 1 db at -65 db re 1 volt/microbar) from 1000 to 6500 cps; thereupon, sensitivity increased to a peak 6 db above that level at 9000 cps; beyond 9000 cps, sensitivity decreased rapidly to about -75 db re 1 volt/microbar at 13000 cps. Manufacturer's specifications stated that the microphone's response was flat between 100 and 1000 cps.

To perform spectrum analyses, the output of the microphone was applied to a Hewlett-Packard 300A wave analyser; the output of the wave analyser was fed through a rectifier-amplifier unit into a synchronized Esterline-Angus AW recording DC millimeter. The effective band width of the system was 45 cps; frequency calibration was accurate within 10 cps at low frequencies and within 100 cps at high.

APPENDIX II

REACTION CHECK LIST ITEMS INTERPRETED AS INDICATING SOMATIC (S), NON-DISTURBED (N-D), AND QUESTIONABLE (?) RESPONSES

?	1. This noise is extremely uncomfortable.
N-D	2. The noise is pleasant and stimulating.
?	3. It is almost unbearable.
?	4. It is fairly upsetting.
S	5. It makes me feel tense all over.
S	6. It makes my heart beat rapidly.
S	7. I feel as if I can't breathe.
S	8. After a while I thought I would faint.
?	9. It makes me very irritable.
?	10. It doesn't really bother me. I just forget about it.
N-D	11. It makes me work harder and think better.
?	12. I can't seem to think or concentrate.
S	13. I get a shaky feeling.
S	14. It makes me nervous.
?	15. I feel tired.
S	16. It gives me a headache.
S	17. It tightens my stomach.
S	18. I feel nauseated.
S	19. There seems to be a "pulling" sensation in my eyes.
N-D	20. I have a ringing in my ears.
S	21. It hurts my ears.
S	22. My knees seem to be shaking.
N-D	23. The noise was discomforting at first but after a while it didn't bother me so much.
N-D	24. The noise isn't pleasant but it doesn't really bother me.
N-D	25. I am surprised to find that I can work under such a loud noise.
?	26. It scares me.
?	27. The palms of my hands are sweating.*

* Palmar sweating was classified as "Questionable" because it was believed that due to its frequency of occurrence in stress situations, it could not be related to stress due to noise.

APPENDIX III

INSTRUCTIONS TO SUBJECTS FOR SESSION I, NOISE CONDITION, TEST FORM A

"Today you will be working under a loud noise much like the noise produced by an airplane." (The booklets were given the subjects, then:) "Please do not open this booklet or turn it over until told to do so. Write your name on the first line. Read the instructions carefully and make sure you understand them thoroughly (pause). You will be allowed thirty minutes to complete this test. At the end of that time we will take the test and hand you a check list. Write your name on this and follow the directions printed at the top. If anyone enters the room while you are working just keep on working until the test is taken away. All that is asked is that you do your own work and do as well as you can. If for any reason you wish to leave the room at any time you may do so."

"The noise will begin now, and gradually becomes louder. When it has reached its maximum level I will drop my hand as a signal for you to begin. Do not begin until I drop my hand."

APPENDIX IV

LISTS OF EQUIVALENT WORDS FOR TASK I

1.	2.	3.	4.	5.
BACK	MILE	SHIP	EACH	THEY
MUCH	BOOK	FEET	MISS	GAME
COME	NOTE	HAVE	DARK	WORK
WAVE	THUS	WISE	SKIN	MINE
REST	WHAT	THEM	WIDE	WANT
SHOW	FEEL	BIRD	FORM	CARE
DEAR	COST	LATE	SHOT	FOOD
NAME	PASS	MOVE	HANG	LIVE
THIS	DROP	ROAD	GREW	INCH
YOUR	GIVE	SOME	WELL	HARD
SORT	GAME	SONG	TURN	BEST
LIFE	NEXT	CALL	THAT	SURE
PART	ROOM	WHEN	GOLD	POST
GIRL	HAND	THIN	JOIN	LONG
TOOK	WISH	SHOP	RUSH	MUST

APPENDIX V

LISTS OF EQUIVALENT STATEMENTS FOR TASK II

LIST 1

1. Replace tires on all airplanes in Squadron 25.
2. Fill all airplanes with 2600 gallons of fuel.
3. Change the engine oil on number three engine.
4. Check fuel gages in all airplanes in Squadron 10.
5. The wind at Moore Field is six miles per hour.
6. The airfield at Greenville is north of the town.
7. The commander of Squadron 95 is Colonel Munn.
8. Fly a heading of 110 degrees to Roberts Field.
9. Hammond Airfield has an elevation of 500 feet.
10. Report all accidents to the Commanding Officer
11. Fly a right traffic pattern at Collins Field.
12. The radio call letters at Greensboro are H-J-L.
13. Radio facilities are closed at Andrews Field.
14. The Kelly Field radio frequency is 247.
15. The fuel capacity of a B60 is 6000 gallons.

LIST 2

1. Fly a heading of 35 degrees to Morgan Field.
2. The call letters at Richburg are C-L-O.
3. Jones Field radio frequency is 835.
4. The north-south runway is closed at Davis Field.
5. Change the oil filter on number four engine.
6. The commander of Group 50 is Colonel Swift.
7. Porter Airfield has an elevation of 1500 feet.
8. Land on paved runway at Burton Field.
9. Fill the left wing tank with 500 gallons of fuel.
10. The oil capacity of a B-42 is fifty gallons.
11. Report all engine failures to the engineering officer.
12. The ceiling at Stevens Field is 600 feet.
13. Check flight controls on all airplanes in Squadron 40.
14. The beacon at Danville is east of the town.
15. Repair the cowling on airplanes in Squadron 50.

LIST 3

1. Fill the fuselage tank with 900 gallons of fuel.
2. The visibility at Dover Field is one-half mile.
3. The elevation of Barton Field is 4000 feet.
4. The airport at Kingston is east of the town.
5. The commander of Squadron 38 is Major Valentine.
6. Check altimeters in all airplanes in Squadron 90.
7. Fly a heading of 165 degrees to English Field.
8. Change the carburetor on number one engine.
9. Land on east-west runway at Smith Field.
10. The call letters at Scottsville are C-R-X.
11. The radio beacon is closed at Gilbert Field..
12. Report all radio failures to the communications officer.
13. Check radios in all airplanes in Squadron 41.
14. Lambert Field radio frequency is 438.
15. The oil capacity of an F-92 airplane is 12 gallons.

LIST 4

1. Take off to the south at Washburn Field.
2. Check landing gear on airplanes in Squadron 15.
3. Evans Field radio frequency is 247.
4. Inform the line chief of all equipment losses.
5. The main runway at Wallace Field is closed.
6. The call letters at Stockton are S-R-A.
7. The elevation of Jones Field is 3000 feet.
8. The fuel capacity of an F-90 is 800 gallons.
9. Fill the right wing tank with 300 gallons of fuel.
10. The commander of Squadron 25 is Major Sutton.
11. Change the spark plugs on number two engine.
12. Remove bombsights on all airplanes in Squadron 43.
13. The river at Central City is west of the town.
14. The wind at Robinson Field is 15 miles per hour.
15. Fly a heading of 75 degrees to Conway Field.

LIST 5

1. Take off to the west at Bellows Field.
2. Radio compasses are to be removed on airplanes in Group 41.
3. Report runway conditions to the tower officer.
4. The Gardenville Racetrack is south of the town.
5. The passenger capacity of a C58 airplane is 42.
6. All operations at Baker Field have been suspended.
7. Check the hydraulic system on all B61 airplanes.
8. Landon Field is 350 miles from the coast.
9. N-Y-T are the radio call letters at Glendale.
10. Fill all airplanes with 3800 gallons of fuel.
11. The elevation of Lockport Airfield is 350 feet.
12. Replace the flywheel on number five engine.
13. Wilson Field radio frequency is 629.
14. The ceiling at Simmons Field is 600 feet.
15. Colonel Clark is the commanding officer of Squadron 819.

APPENDIX VI

LISTS OF EQUIVALENT DIAL SETTINGS FOR TASK III

LIST 1

1. Set the red and yellow dial at 5.
2. Set the yellow dial at 49.
3. Set the green dial at 48.
4. Set the blue dial at 74.
5. Set the orange dial at 14.
6. Set the gray dial at 44.
7. Set the white dial at 22.
8. Set the black dial at 64.
9. Set the red dial at 65.
10. Set the black and white dial at 47.

LIST 2

1. Set the blue dial at 24.
2. Set the gray dial at 34.
3. Set the red dial at 55.
4. Set the black and white dial at 64.
5. Set the yellow dial at 40.
6. Set the orange dial at 53.
7. Set the red and yellow dial at 17.
8. Set the white dial at 91.
9. Set the green dial at 43.
10. Set the black dial at 44.

LIST 3

1. Set the red dial at 81.
2. Set the gray dial at 28.
3. Set the green dial at 38.
4. Set the black and white dial at 54.
5. Set the red and yellow dial at 61.
6. Set the blue dial at 59.
7. Set the black dial at 8.
8. Set the orange dial at 72.
9. Set the yellow dial at 21.
10. Set the white dial at 37.

LIST 4

1. Set the green dial at 85.
2. Set the yellow dial at 84.
3. Set the black dial at 87.
4. Set the red dial at 73.
5. Set the black and white dial at. 89.
6. Set the gray dial at 2.
7. Set the red and yellow dial at 32.
8. Set the white dial at 27.
9. Set the orange dial at 7.
10. Set the blue dial at 48.

LIST 5

1. Set the gray dial at 26.
2. Set the yellow dial at 11.
3. Set the red and yellow dial at 73.
4. Set the green dial at 92.
5. Set the blue dial at 54.
6. Set the orange dial at 61.
7. Set the white dial at 100.
8. Set the black dial at 57.
9. Set the red dial at 2.
10. Set the black and white dial at 81.

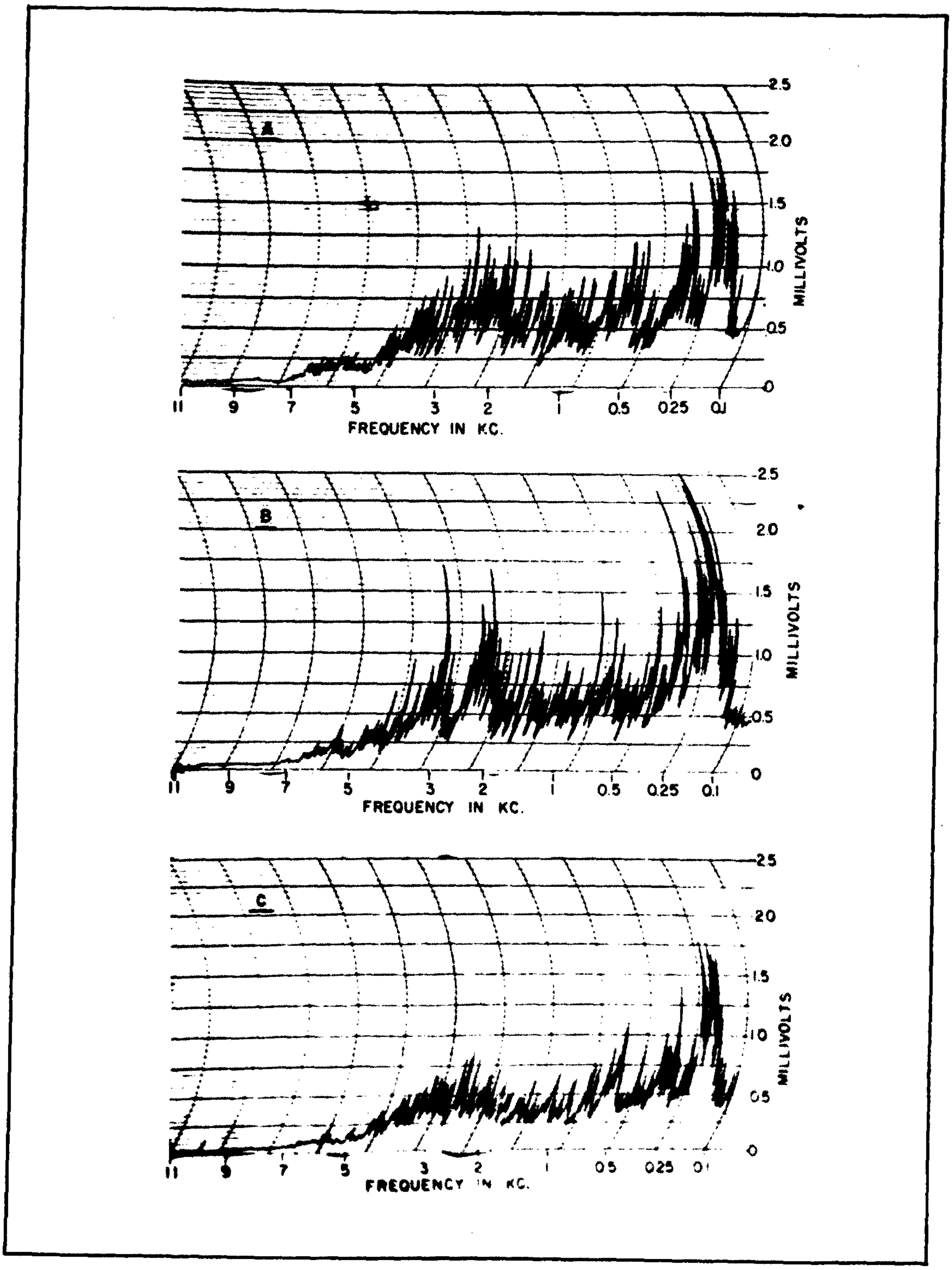
APPENDIX VII

PRODUCTION OF HIGH INTENSITY NOISE

The sound generated for this study was of such quality and intensity that it was referred to as "synthetic airplane noise". The noise generator consisted of a circuit in which a gas triode (RCA A884) was made to conduct continuously. The random potentials produced by the ionization involved were led in parallel to two amplifiers: (1) a Western Electric 142-B amplifier and (2) a Bogen EX-35 amplifier. From the Western Electric amplifier, the signal was led in parallel to two Jensen A-12-PM speakers; from the Bogen amplifier, to a Western Electric 722A A-15-PM console speaker. Typical noise spectra obtained from the loudspeakers are shown in Appendix VIII.

APPENDIX VIII

SOME TYPICAL NOISE SPECTRA



APPENDIX IX

REACTION CHECK LIST (SOMATIC COMPLAINT SCALE) WITH GENERALITY (G) AND SPECIFICITY (S) DESIGNATIONS

G 1. Nervous

G 2. Excessively tired

S 3. Constipated

G 4. Loss of appetite

S 5. Diarrhea (loose bowels)

S 6. Excessive thirst

___ 7. Backache

G 8. Sore muscles

S 9. Pain in the eyes

S 10. Headache

S 11. Pain in the ears

S 12. Trembling fingers

S 13. Pains in the legs

S 14. Pains in the arms

S 15. Upset stomach

S 16. Burning sensation in the eye

S 17. Pains in the shoulders

___ 18. Weakness in the knees

G 19. Dizziness

G 20. Feeling irritable or anger

S 21. Swollen feeling in tongue

___ 22. Difficulty in breathing

S 23. Sneezing spells

S 24. Coughing spells

S 25. Difficulty in urinating

S 26. Excessive sweating of the hands

G 27. Difficulty falling asleep

S 28. Excessive sweating of the feet

___ 29. Pains in the chest

___ 30. Quickening of the heart-beat

S 31. Hotness or fever

___ 32. Pressure in the chest region

S 33. Numbness in the hands

S 34. Numbness in the feet or legs

S 35. Difficulty in swallowing

S 36. Dryness in the mouth

___ 37. Lump in the throat

G 38. Cold or clammy feeling

___ 39. Stomach pains

___ 40. Pains in the kidney region

G 41. Stiffness of the muscles

G 42. Excessive restlessness

G 43. Particular difficulty in waking up in the morning

__ 44. Soreness of the joints

S 45. Stiffening of the fingers

S 46. Heartburn

__ 47. Pain in the sinus region

G 48. Shaky feeling

S 49. Coldness in hands or feet

S 50. Acid stomach

__ 51. Tingling sensation in arms or legs

__ 52. Dull pains in pit of stomach

__ 53. Fullness in the head or nose

S 54. Vomiting

G 55. Parts of body feel sensitive

G 56. Get tired quickly

G 57. Everything tastes flat

S 58. Skin breaks out in rash or pimples

S 59. Bothered by ringing in the ears

__ 60. Choking sensation in the throat

__ 61. Pressure in the heart region

__ 62. Excessive blushing (reddening of the skin)

__ 63. Difficulty maintaining balance

__ 64. Indigestion

G 65. General weak feeling

G 66. Too tired to eat

S 67. Running nose

S 68. Severe itching

G 69. Faint feeling

G 70. Hot spells

G 71. Cold spells

S 72. Sore throat

S 73. Teeth hurt

S 74. Feet exceptionally tired

__ 75. Muscles tense

__ 76. Tension in chest or stomach

__ 77. Trembling muscles

G 78. Inability to relax

S 79. Biting fingernails

G 80. Difficulty in digesting food

S 81. Twitching muscles

__ 82. Excessive smoking

S 83. Stiff or sore neck

S 84. Pains in the armpits

G 85. Excessive body perspiration

INSTRUCTIONS TO SUBJECTS FOR
PRE-TEST REACTION CHECK LIST

NAME______________________________ DATE______________
(Please Print)

INSTRUCTIONS

On the following pages you will find a series of statements. The object of this task is for you to place an "X" beside those statements which describe the way you've felt in the past forty-eight hours.

There are no "right" or "wrong" answers in this task. There is no time limit. This is not a test. The only important thing for you to remember is to place an "X" beside each statement which describes the way you feel now or the way you've felt in the past two days. You may "X" as many statements as you feel is necessary for an accurate description. You may turn the page and begin.

INSTRUCTIONS TO SUBJECTS FOR POST-TEST REACTION CHECK LIST

NAME____________________________________ DATE________________
(Please Print)

INSTRUCTIONS

On the following pages you will find a series of statements. The object of this task is to go through the list and place an "X" beside those statements which describe the way you felt when you were being exposed to the noise during the past hour. When you have done this, go through the list again and place a circle (0) beside those statements which describe the way you've felt during the past forty-eight hours. For example: If a man felt that his ears were ringing now and had a headache, while yesterday he had a headache and was nauseated, he would mark the item as follows:

X Ears ringing

X-O Headache

O Feel nauseated

There are no "right" or "wrong" answers in this task. There is no time limit. This is not a test. Your performance score will not be affected by your answers on this check list. We are interested only in how the noise affects you.

Remember:

X - means you feel that way now

O - means you've felt that way in the past two days

X-O - means you feel that way now and also felt that way in the past two days

You can mark as many statements as you feel is necessary for an accurate description. You may turn the page and begin.

APPENDIX X

WORK TASK W X Y Z

NAME_______________________________DATE______________

DIRECTIONS

On the following page you will find two words. The object of this task is for you to write down as many meaningful English words as you can which rhyme with the given words. Do not write down slang words, or words without meaning. Only meaningful English words will be counted as correct.

EXAMPLE: <u>LEAVE</u>

believe
achieve
conceive
Genevieve
cleave

When the lights are turned out, turn to the next page. When the lights are turned on again, begin writing words which rhyme with the words given. <u>DO NOT TURN THIS PAGE UNTIL THE LIGHTS ARE TURNED OUT</u>.

You will have ten minutes to complete this task. Work as quickly as you can.

T__________________ I______________________

C______________________

1

CAR	BLISS

APPENDIX XI

LISTS OF NONSENSE MATERIAL IN LEARNING-RETENTION STUDY

Pair No.	List 1		List 2		List 3		List 4	
1	4G8	FEP	2P3	HAJ	7S5	HUJ	8R3	KEJ
2	2H4	MAF	7J8	MIV	3S6	VEF	7Q5	VOF
3	9F7	VUK	1C9	YOJ	2Y3	ZOJ	8F1	BIW
4	3T2	PEJ	7H9	FUP	3R7	POB	5P7	TUJ
5	4S1	WOF	2G4	VAB	6W3	YUF	8L6	JID
6	7G6	JIH	9W3	ZUD	5Q3	MEV	9J5	ZIB
7	9K1	ZUX	5V3	KIH	9Z4	BUW	2D1	WOJ
8	5W1	MUJ	4H3	ZIK	2D7	ZIH	3Y6	NUV
9	1B3	LAJ	1Y5	KUJ	8Q2	DEJ	3S2	YUX
10	5A9	ZID	6J1	WOB	2F1	ZAL	8D4	NIJ